PORTLAND HARBOR SUPERFUND SITE ECOLOGICAL RISK ASSESSMENT:

APPROACH FOR THE PRELIMINARY RISK EVALUATION FOR ECOLOGICAL RECEPTORS

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LIST OF ACRONYMS

BERA	Baseline Ecological Risk Assessment
BSAF	biota-sediment accumulation factor
bw	body weight
Round 2 Comprehensive Report	Comprehensive Round 2 Site Characterization Study and Data Gap Analysis Report
COI	chemical of interest
COPC	chemical of potential concern
CSM	conceptual site model
DL	detection limit
dw	dry weight
ERA	Ecological Risk Assessment
FIR	food ingestion rate
HHRA	Human Health Risk Assessment
HQ	hazard quotient
ISA	initial study area
LWG	Lower Willamette Group
LOAEL	lowest-observed-adverse-effect level
LOEC	lowest-observed-effect concentration
NOAEL	no-observed-adverse-effect level
NOEC	no-observed-effect concentration
OC	organic carbon
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PRE	Preliminary Risk Evaluation
Programmatic Work Plan	Portland Harbor Remedial Investigation/ Feasibility Study Programmatic Work Plan
RM	river mile
SCRA	site characterization and risk assessment
SI	sediment ingestion
SPI	sediment profile imaging
TEF	toxic equivalency factor
TEQ	toxic equivalent quotient
TRV	toxicity reference value
UCL	upper confidence limit
ww	wet weight

1.0 INTRODUCTION

The Ecological Risk Assessment (ERA) approach for the Portland Harbor Superfund Site was outlined in the *Portland Harbor Remedial Investigation/Feasibility Study (RI/FS) Programmatic Work Plan* (Integral et al. 2004a), which was approved by the US Environmental Protection Agency (EPA) in April 2004. The overall ERA approach follows the *Guidelines for Ecological Risk Assessment* (EPA 1998) and consists of three major components: problem formulation, analysis, and risk characterization (EPA 1997, 1998). The ERA will be an iterative process, with an assessment of ecological risks accomplished through the production of several major deliverables: 1) *Preliminary Risk Evaluation* (PRE), 2) *Comprehensive Round 2 Site Characterization Summary and Data Gap Analysis Report* (Round 2 Comprehensive Report), and 3) *Baseline Ecological Risk Assessment* (BERA). In addition to historical data, multiple rounds of data collection (i.e., Round 1, Round 2, and subsequent rounds if necessary) are being undertaken to provide site-specific data relevant to assessing ecological risks.

This technical memorandum presents the approaches and methods that will be used in the PRE. A separate technical memorandum will present the approaches and methods that will be used in the Round 2 Comprehensive Report and in the BERA. The PRE is an interim analysis expected to assist in the risk assessment process by facilitating a better understanding of the conceptual site model (CSM) and assisting in future discussions regarding data and information gaps. The PRE will be conducted using conservative (i.e., protective) exposure assumptions, with the purpose of identifying chemical/receptor pairs on which to focus more detailed analyses and/or identifying potential data/information gaps to be filled in order to complete the ERA process. If conservative assumptions are used, it can be assumed that any chemical/receptor pairs that are shown in the PRE to present negligible risks are highly unlikely to present significant risks in subsequent assessments, unless substantially different data (e.g., much higher chemical concentrations) are generated in subsequent sampling rounds. In addition, for purposes of comparison, exposures calculated using less conservative approaches (i.e., upper 95th percentile exposure point concentrations) will also be presented in the PRE.

The PRE will be based on data collected as part of the Round 1 data collection effort and on relevant existing historical data. Because ERA sampling in Round 1 targeted mainly fish tissues and sediments, the PRE will focus on assessing preliminary risks to fish and wildlife receptors. In the PRE, all detected analytes found in historical and Round 1 data will be identified as chemicals of interest (COIs). Chemicals of potential concern (COPCs) will be identified from the list of COIs for fish and wildlife receptors based on applying protective exposure assumptions. The PRE also will identify initial tissue-residue-based COPCs for benthic invertebrates using the tissue data for crayfish and clam samples collected during Round 1 sampling.

The remainder of this technical memorandum is organized as follows:

- Section 2 briefly presents the objectives and scope of the PRE, including a summary of the assessment endpoints, receptors, and selected measures that will be evaluated in the PRE as outlined in the Programmatic Work Plan.
- Section 3 presents a summary of the data that will be used in the PRE, including Round 1 surface sediment and whole-body tissue data, Round 1 co-located sediment/tissue data, and historical surface sediment data.
- Section 4 presents the methods for evaluating the relationship between sediment and tissue concentrations based on the Round 1 co-located data.
- Section 5 presents the methods and assumptions that will be used to estimate exposure in the PRE for benthic invertebrates (using the tissue-residue approach), fish, birds, and mammals.
- Section 6 presents the methods that will be used in the PRE for characterizing adverse effects for the Portland Harbor Superfund Site.
- Section 7 presents the methods for calculating preliminary ecological risk estimates in the PRE to identify an initial list of COPCs for relevant pathways for the Portland Harbor Superfund Site.
- Section 8 presents the uncertainty and limitations associated with the PRE.
- Section 9 presents methods for determining how data and information gaps associated with the analysis of Round 1 data will be identified in the PRE.
- Section 10 lists references cited in this technical memorandum.

2.0 OBJECTIVES AND SCOPE OF THE PRE

The PRE will include a preliminary risk characterization based on historical and Round 1 data for benthic invertebrates (using the tissue-residue approach line of evidence), fish, and wildlife (i.e., birds and mammals). Results will be used, in part, to help identify an initial list of COPCs for invertebrate tissue, fish, and wildlife. The initial list of COPCs will be updated following Round 2 sampling and analysis (and any subsequent sampling rounds, as necessary). The preliminary risk estimates and the associated uncertainty will help to identify ERA data and information gaps that may be filled during subsequent investigations and evaluations prior to the BERA.

Specifically, the objectives of the PRE are as follows:

- Perform preliminary exposure and risk calculations for benthic invertebrates (using a tissue-residue approach), fish (both dietary and tissue-residue approach), and wildlife (dietary exposure) using historical and Round 1 sediment and tissue data. Risks will be characterized by comparing highly conservative exposure estimates to effect concentrations (i.e., toxicity reference values [TRVs]).
- Evaluate relationships between COI concentrations in sediment and tissues of invertebrate (i.e., crayfish) and fish (i.e., sculpin) species to determine if usable biota-sediment accumulation factors (BSAFs) can be derived. Site-specific BSAFs could be used to predict COI concentrations in tissue based on concentrations in sediment.
- Identify an initial list of COPCs based on exceedance of TRVs or on uncertainty (e.g., available data are insufficient to make a conclusion of negligible risk).

The PRE will present exposure estimates based on a highly conservative, screening-level evaluation. The Round 2 Comprehensive Report and BERA will modify exposure estimates using more realistic assumptions of the exposure conditions of ecological receptors in the Portland Harbor Superfund Site, and these exposure assumptions will be developed for risk analysis.

2.1 ASSESSMENT ENDPOINTS

Only benthic invertebrates, fish, and wildlife receptor groups will be evaluated in the PRE. Other lines of evidence for these receptor groups (e.g., the direct toxicity assessment for the benthic invertebrate community) and a more comprehensive characterization of ecological risks for all receptor groups evaluated in the PRE will be presented in the Round 2 Comprehensive Report and the BERA. Other receptor groups (i.e., aquatic plants and amphibians/reptiles) will be evaluated following

Round 2 surface water sampling and data analysis in the Round 2 Comprehensive Report and the BERA.

The selection of assessment endpoints and ecological receptors of concern is discussed in Appendix B of the Programmatic Work Plan (Integral et al. 2004a). The assessment endpoints are survival, growth, and reproduction for all receptors, with the exception of juvenile chinook salmon. The assessment endpoints for juvenile chinook salmon are survival and growth only, because chinook salmon are present in Portland Harbor as juveniles and briefly as adults returning from spawning migrations. Spawning does not occur in Portland Harbor for chinook salmon. The representative ecological receptor species that will be evaluated in the PRE are the following:

- Shellfish (clams [*Corbicula fluminea*])
- Epibenthic macrofauna (crayfish [*Pacifastacus* spp.])
- Omnivorous/herbivorous fish (largescale sucker [*Catostomus macrocheilus*], carp[1] [*Cyprinus carpio*])
- Invertivorous fish (sculpin [*Cottus* spp], peamouth [*Mylocheilus caurinus*], juvenile chinook salmon [*Oncorhynchus tshawytscha*])
- Piscivorous fish (northern pikeminnow [*Ptychocheilus oregonensis*], smallmouth bass [*Micropterus dolomieui*])
- Invertivorous/omnivorous birds (spotted sandpiper [*Actitis macularia*])
- Carnivorous/omnivorous birds (hooded merganser [*Lophodytes cucullatus*])
- Piscivorous birds (bald eagle [*Haliaeetus leucocephalus*], osprey [*Pandion haliaetus*])
- Carnivorous mammals (mink [*Mustela vison*], river otter [*Lutra canadensis*])

Two ecological fish receptors will not be evaluated in the PRE: white sturgeon (*Acipenser transmontana*) and Pacific lamprey (*Lampreta tridentata*) ammocoetes, representing omnivorous/herbivorous and detritivorous feeding guilds, respectively. No whole-body tissue data are available at this time for these fish species.

2.2 SELECTED MEASURES

The selection of measures to evaluate the assessment endpoints for the selected receptors is discussed in Appendix B of the Programmatic Work Plan (Integral et al.

[1] Carp will be used as a surrogate ecological fish receptor species to evaluate dioxins and PCB congeners in whole-body tissue.

2004a). Detail on the rationale for the selection of these measures is provided in the Programmatic Work Plan.

The selected measures that will be used to evaluate the assessment endpoints in the PRE are presented in the following subsections. Other measures will be evaluated in the Round 2 Comprehensive Report and in the BERA once additional data (e.g., Round 2) become available. The measures that will be evaluated in the PRE will be used to identify the initial list of COPCs for the ERA.

2.2.1 Benthic Invertebrate Receptors

The analysis in the PRE will focus on effects on the survival, growth, and/or reproduction of benthic invertebrate receptors (i.e., crayfish and clams) using a tissue-residue approach. Chemical analyses were conducted on whole-body crayfish and clam tissue as part of the Round 1 sampling. The whole-body tissue concentrations will be compared to appropriate critical tissue-residue TRVs (see Section 6.0).

Statistical analysis also will be conducted to examine the relationship between chemical concentrations in crayfish tissue and chemical concentrations in co-located sediment collected as part of the Round 1 sampling. If a predictive relationship is observed (described further in Section 4.1), this regression analysis may be used to model invertebrate tissue concentrations in Portland Harbor.

2.2.2 Fish Receptors

Risks to the survival, growth, and/or reproduction of fish will be assessed using two separate methods (i.e., tissue-residue-based risk analysis and diet-based risk analysis) in the PRE, depending on the specific chemicals being assessed.

Chemicals that tend to bioaccumulate in fish (i.e., dioxins, polychlorinated biphenyls [PCBs], mercury, pesticides, and certain other organic chemicals) will be evaluated using the tissue-residue approach. The whole-body tissue concentrations measured in Round 1 sampling will be compared to appropriate critical tissue-residue TRVs (see Section 6.0).

For chemicals that are metabolized or otherwise regulated by the fish (such as polycyclic aromatic hydrocarbons [PAHs] and certain metals), a tissue-residue approach is not appropriate (McCarty and MacKay 1993). Instead, these chemicals will be evaluated using a dietary approach. The dietary approach incorporates exposure to biota (prey) and sediment. Chemical concentrations in the dietary items will be estimated using available prey (fish and invertebrate) tissue and surface sediment data, and these dietary concentrations will be compared to appropriate dietary TRVs (see Section 6.0).

A linear regression analysis will also be conducted to examine the relationship between chemical concentrations in sculpin tissue and chemical concentrations in co-located sediment collected during the Round 1 sampling. If a predictive relationship is observed (described further in Section 4.1), this regression analysis will be used to predict sculpin tissue concentrations in areas of Portland Harbor where sediment data are available but tissue data are lacking. If no statistically predictive relationship is determined from the linear regression, application of a mass-balance mechanistic food web model will be investigated in an upcoming technical memorandum, *Selection of an Aquatic Food Web Model for the Portland Harbor Superfund Site*. Application of this approach would be necessary only for sculpin because the other fish used as prey items in the risk assessment have larger foraging ranges (i.e., the tissue concentrations in other fish would not be expected to have a relationship to site-specific sediment concentrations) and would be represented by the collected tissue samples.

2.2.3 Wildlife Receptors

Risks to the survival, growth, and/or reproduction of wildlife receptors (birds and mammals) will be assessed by estimating dietary exposure. Dietary exposure will be expressed as a body weight (bw)-normalized daily dose (mg/kg bw/day) derived from diet using chemical concentrations measured in biota (prey) and sediment. Concentrations in the diet will be estimated using available prey (fish and invertebrate) tissue and surface sediment data and will be compared to appropriate dietary TRVs (see Section 6.0).

3.0 SUMMARY OF DATA USED IN THE PRE

This section presents a summary of the available data that will be used in estimating exposure in the PRE for benthic invertebrates, fish, and wildlife. Available data include surface sediment and tissue data collected in Round 1 sampling and historical data collected after 1990. The methods that will be used to reduce data (e.g., calculating totals and determining single concentrations where replicate or duplicate samples were taken) are also presented.

The PRE exposure estimates based on historical and Round 1 data will be modified once the Round 2 surface sediment data are available. In addition, exposure estimates based on Round 2 surface water data also will be calculated. These exposure estimates will be presented in the Round 2 Comprehensive Report and the BERA.

3.1 ROUND 1 SAMPLING

Round 1 sampling of Portland Harbor was conducted in the summer and fall of 2002 and is summarized in the *Portland Harbor Remedial Investigation/Feasibility Study Round 1 Field Sampling Report* (SEA et al. 2003). Round 1 sampling for the ERA included the collection of fish and invertebrate (i.e., crayfish and clams) whole-body tissue samples and surface sediment samples for chemical analyses. These data will be used in estimating exposure in the PRE for benthic invertebrates, fish, and wildlife. Round 1 data are presented in the following subsections.

3.1.1 Surface Sediment Data

In Round 1, 58 surface (0-15 cm) sediment samples were collected from river mile (RM) 2 to RM 10 of Portland Harbor (Figure 3-1) from October to November 2002. Surface sediments were collected for analysis from 27 locations co-located with tissue samples, 11 nearshore or in-channel locations, and 20 beach locations. All of these Round 1 samples will be used in estimating dietary exposure in the PRE. Table 3-1 presents a summary of the chemicals analyzed in surface sediment samples to be used in the PRE, including the Round 1 data.

3.1.2 Tissue Data

In Round 1, 110 fish and invertebrate tissue samples were collected from RM 2 to RM 10 of Portland Harbor (Figure 3-2[2]) in the summer and fall of 2002. Whole-body tissue samples were collected for nine fish species: largescale sucker, carp, juvenile chinook salmon, sculpin, peamouth, smallmouth bass, northern pikeminnow, black crappie, and brown bullhead. In addition, whole-body tissue samples were collected

[2] The sampling locations of three fish species (i.e., carp, brown bullhead, and black crappie) collected in support of the Human Health Risk Assessment (HHRA) are not identified in Figure 3-2. Composites for these fish species were collected over three-mile fishing zone (FZ) segments of the Portland Harbor Superfund Site (see Table 3-2 for the number of composites collected within each FZ segment).

for two invertebrate species: crayfish and clams. Pacific lamprey ammocoetes could not be collected in sufficient numbers to conduct tissue analyses. White sturgeon tissue samples were not collected in Round 1 sampling. White sturgeon and Pacific lamprey ammocoete whole-body tissue concentrations will be modeled, and/or additional data will be collected in future rounds of sampling (e.g., Round 3). Risks to these fish species will not be assessed in the PRE.

Table 3-2 presents a summary of the fish and invertebrate composites collected at each Round 1 tissue sampling location. Whole-body tissue samples from the nine aquatic ecological receptors (i.e., largescale sucker, carp,[3] juvenile chinook salmon, sculpin, peamouth, smallmouth bass, northern pikeminnow, crayfish, and clams) will be used to represent tissue-residue exposure concentrations for the PRE. Whole-body tissue samples from all eleven aquatic receptors will be used to estimate dietary exposure for fish and wildlife ecological receptor species in the PRE. Table 3-3 presents a summary of the number of composite tissue samples and the chemicals analyzed in these samples.

3.2 ROUND 1 CO-LOCATED SEDIMENT AND TISSUE DATA

As part of Round 1 sampling, 27 co-located surface sediment samples were collected. Twenty-four sculpin tissue samples, 23 crayfish tissue samples, and 3 clam tissue samples were co-located with these sediment samples. The locations of these co-located sediment and tissue samples are presented in Table 3-4 and Figure 3-3.

3.3 HISTORICAL SEDIMENT DATA

Historical data were compiled for the Portland Harbor Superfund Site and presented in the Programmatic Work Plan (Integral et al. 2004a). The historical dataset included surface water, sediment, tissue, and toxicity test data collected within the Portland Harbor Superfund Site since 1990. Historical sediment and tissue data were considered for use in the PRE as a supplement to the sediment and tissue data collected in Round 1. The quality of historical data sets was evaluated prior to their consideration for use in the PRE. Data qualified as Category 1 had acceptable and documented data quality criteria (i.e., traceability, comparability, sample integrity, potential measurement bias, accuracy, and precision) and were considered acceptable for use in the PRE. Category 2 data were not considered acceptable for use in the PRE because data quality criteria were unmeasured, unreported, or unacceptable.

The available historical sediment and tissue data are described in the following two subsections.

[3] Carp was collected in support of the HHRA but will also be used as a surrogate ecological receptor for dioxin and PCB congener analysis in whole-body tissue.

3.3.1 Surface Sediment Data

Sediment data collected from recent (post-1990) sampling events are identified in the Programmatic Work Plan (Integral et al. 2004a). All sediment data qualified as Category 1 were considered acceptable for use in the PRE. Historical sediment data included surface and subsurface samples. For the purposes of the PRE, only surface sediment samples collected from within the top 15 cm of the sediment horizon will be used. In addition, only historical surface sediment samples located between RM 2.0 and RM 9.2 will be used in estimating dietary exposure in the PRE (Figure 3-4). The majority (approximately 85%) of Category 1 surface sediment data available in the historical sediment database is located within these RM boundaries. A total of 674 historical sediment samples will be used for estimating dietary exposure. Table 3-1 presents a summary of the chemicals analyzed in surface sediment samples, including historical (Category 1) data.

3.3.2 Tissue Data

Tissue data from historical sampling events identified in the Programmatic Work Plan (Integral et al. 2004a) were not considered acceptable for use in the PRE because all of those data were qualified as Category 2. No historical tissue data will be used to estimate exposure in the PRE.

3.4 DATA REDUCTION

The draft technical memorandum, *Guidelines for Data Reporting, Data Averaging and Treatment of Non-detected Values for the Round 1 Database* (Kennedy/Jenks et al. 2004), presents the rules to be followed for development of the Round 1 site characterization and risk assessment (SCRA) database. Rules were established for data reduction (i.e., where multiple analytical methods were used or where laboratory or field duplicates, replicates, or split samples were analyzed). These guidelines were applied to both Round 1 and historical data, where applicable.

In Round 1, multiple results for the same chemicals in a sample were reported in cases where multiple analytical methods were used, and where laboratory or field duplicates, replicates, or split samples were analyzed. In cases where multiple results were reported from multiple analytical methods, the reported value in the Round 1 database will be based on the preferred analysis method. Where multiple results were reported in the cases of laboratory duplicates, replicates, or splits, averages will be calculated to determine a single concentration for a specific chemical at a field location. When both values were detected, an average of the detected results will be reported. When neither value was detected, the lower detection limit of the two undetected results will represent the reported result in the database. When one value was detected and the other was not detected, the detected and full detection limit of the non-detected result will be averaged if the detection limit is lower than the

detected concentration. If the detection limit is higher than the detected concentration, the detected concentration will represent the average value.

"Total" concentrations will be calculated for DDTs, PCB Aroclors, and polycyclic aromatic hydrocarbons (PAHs) in the Round 1 and historical surface sediment databases using the following summation rules. When calculating sums, in samples where any or all chemicals contributing to the sum were detected, a sum of the detected values will represent the total. In samples where no chemicals contributing to the sum were detected, the highest detection limit will represent the sum and will be qualified as non-detected. In addition, for dioxins and PCB congeners, toxic equivalent quotient (TEQ) concentration sums will be calculated (for dioxins and PCB congeners separately). TEQs will be based on World Health Organization (WHO)-derived toxic equivalency factors (TEFs) for fish, birds, and mammals. The most recently published WHO TEFs available during the risk assessment process will be used, unless EPA develops or adopts other values.

4.0 EVALUATION OF CO-LOCATED SEDIMENT AND BIOTA

To determine if a site-specific predictive relationship can be derived, co-located sediment and tissue concentrations will be evaluated. Round 1 sediment samples co-located with sculpin and crayfish tissue samples will be used in this evaluation. A regression approach or other evaluation will be used to evaluate the feasibility of deriving a site-specific predictive relationship. The methods for deriving and applying a predictive relationship to estimate tissue concentrations using sediment concentrations measured throughout Portland Harbor are presented in the following sections.

4.1 STATISTICAL EVALUATION

A tiered approach will be used to investigate the correlation between chemical concentrations in sediment and tissue. For organic compounds, tissue concentrations will be lipid normalized and sediment concentrations will be organic carbon (OC) normalized,[4] metals concentrations will not be normalized. A regression of the sediment vs. tissue data will be plotted to determine whether concentrations are independent or co-vary. Correlation between sediment and tissue concentrations will be measured with a Spearman's rank correlation. The relationship between tissue and sediment may be linear, logarithmically linear, or some other monotonic or threshold function. Spearman's rank correlation test is preferred over Pearson's linear correlations test because it will identify any type of monotonic relationship between sediment and tissue, and it is also less influenced by outlier data points. If a strong linear correlation is present, Spearman's test will detect it, whereas Pearson's linear correlation test may fail to detect a non-linear relationship. A one-tailed test for independence using Spearman's rank correlation coefficient takes the following form (Conover 1980):

- H_0: There is mutual independence between tissue concentrations and sediment concentrations (rank correlation = 0)
- Ha: There is a tendency for larger values of tissue concentrations to be associated with larger values of sediment concentrations (rank correlation > 0)

An α-level (the probability of committing a Type I error [rejecting H_0, when in fact H_0 is true]) will be selected in order to limit the experimental Type I error rate to a reasonable level. When the one-tailed p-value is less than the selected α-level, it will be concluded that the tissue and sediment concentrations are dependent and there is a positive correlation between these concentrations. For chemicals found to co-vary, the

[4] Non-normalized tissue and sediment data will also be considered for organic compounds, to determine if a correlation exists between wet-weight tissue and dry-weight sediment concentrations.

nature of the correlation between tissue and sediment concentrations will be investigated. The distribution of sediment and tissue data will be evaluated for normality.

4.2 DERIVATION OF PREDICTIVE ALGORITHMS

If sediment and tissue concentrations for a particular analyte are found to be mutually dependent and there is a positive correlation between these concentrations, it may be possible to derive a site-specific BSAF for that analyte. BSAFs express the steady-state relationship between the concentration of a bioaccumulating nonpolar organic chemical normalized on the organic carbon content of sediment and the concentration measured in the total extractable lipids of an organism for which that sediment represents the source of contamination in its habitat. BSAFs can be derived using the following equation:

$$BSAF = \frac{C_{WB} \div F_L}{C_{sed} \div F_{OC}} \qquad \textbf{Equation 4-1}$$

Where:

C_{WB} = chemical concentration in whole-body fish or invertebrate tissue (mg/kg wet weight [ww])
C_{sed} = chemical concentration in sediment (mg/kg ww)
F_L = fraction lipid of the whole-body fish or invertebrate tissue (kg lipid/kg ww)
F_{OC} = fraction organic carbon in sediment (kg OC/kg dw)

Where the sample size of co-located tissue and sediment data is limited or where positive correlations between sediment and tissue are not identified, a linear approach may not be feasible. Alternatively, individual BSAFs may be calculated for each co-located sediment and tissue location, and the mean and variance of these BSAF ratios will be calculated. Based on this evaluation, alternate predictive algorithms for expressing the relationship between sediment and tissue will be explored.

4.3 APPLICATION OF BSAF

Site-specific BSAFs (or other predictive algorithms) may be used to derive tissue (i.e., sculpin and crayfish) concentrations from the Round 1 and historical surface sediment chemistry data. These results will be reported in the PRE and, where necessary and applicable, used to estimate dietary exposure.

Tissue concentrations may be derived from sediment concentrations using the following two equations:

$$C_{tiss,LN} = BSAF \times [C_{sed} \div F_{OC}] \qquad \textbf{Equation 4-2}$$

Where:

$C_{tiss,LN}$ = estimated tissue concentration, lipid normalized (mg/kg lipid)
BSAF = fish or invertebrate site-specific BSAF (kg OC/kg lipid)
C_{sed} = surface sediment concentration (mg/kg dw)
F_{OC} = fraction organic carbon in sediment (kg OC/kg dw)

And:

$$C_{tiss} = [C_{tiss,LN}] \times F_L \qquad \textbf{Equation 4-3}$$

Where:

C_{tiss} = estimated tissue concentration (mg/kg ww)
$C_{tiss,LN}$ = estimated tissue concentration, lipid normalized (mg/kg lipid)
F_L = fraction lipid of the whole-body fish or invertebrate tissue (kg lipid/kg ww)

5.0 CHARACTERIZATION OF EXPOSURE

Exposure characterization describes potential or actual contact or co-occurrence of stressors (e.g., COIs) with selected receptors (EPA 1998). This section describes how exposure will be characterized in the PRE for benthic invertebrates, fish, and wildlife. Exposure will be estimated in the PRE for crayfish and clams (using the tissue-residue approach), fish (using either the dietary or whole-body tissue approach, depending on the chemical), and wildlife (using the dietary approach). The calculation methods and algorithms that will be used to derive dietary exposure concentrations in the PRE are presented in Section 5.1. The assumptions that will be used to derive dietary exposure concentrations for fish and wildlife in the PRE are presented in Section 5.2.

Exposure estimates in the PRE will be consistent with screening-level exposure estimates (EPA 1997). EPA (EPA 1997) recommends calculating screening level exposure estimates using the highest measured concentrations for each environmental medium used (i.e., sediment and tissue) so that potential ecological threats are not missed. Thus, exposure will be estimated in the PRE using the highest sediment and tissue concentrations from the relevant data. Conservative assumptions (e.g., 100% of diet consists of the most contaminated dietary component, 100% site use) are also recommended at the screening level (EPA 1997), and such conservative assumptions will be used in the PRE. The conservative assumptions used for estimating exposure in the PRE will be used to identify an initial list of COPC/receptor pairs using available Round 1 and historical data. As more data become available (e.g. Round 2), more realistic assumptions will be made to characterize exposure in the Round 2 Comprehensive Report and the BERA.

In addition to screening-level exposure estimates, more realistic exposure point concentrations (EPCs) also will be calculated using a 95% upper confidence limit of the mean (95% UCL) on relevant media concentrations (i.e., sediment and/or tissue). Lognormal distribution of whole-body tissue data will be assumed in the PRE when calculating the 95% UCL using the following equation (EPA 1992):

$$UCL = e^{\left(\frac{m + 0.5s^2 + sH}{\sqrt{n-1}}\right)} \qquad \textbf{Equation 5-1}$$

Where:

UCL	=	upper confidence limit
e	=	constant (base of the natural log, equal to 2.718)
m	=	mean of the natural log transformed data
s	=	standard deviation of the transformed data
H	=	H-statistic
n	=	number of samples

In the PRE, a statistical analysis on the distribution of all Round 1 and historical data will not be conducted. All data will be assumed to be lognormally (natural log) distributed for the PRE. This assumption will be evaluated in the uncertainty section of the PRE. The 95% UCL tissue and sediment exposure point concentrations in the PRE will be presented for discussion purposes only to provide exposure estimates that may more accurately reflect exposure concentrations. In the Round 2 Comprehensive Report and the BERA, the underlying distribution of the data will be determined so that the appropriate statistics can be computed.

5.1 EXPOSURE ASSESSMENT

Exposure to COIs will be estimated for benthic invertebrates, fish, and wildlife. The methods and algorithms that will be used to calculate exposure concentrations in the PRE are presented in the following subsections, by receptor group.

5.1.1 Exposure Assessment for Benthic Invertebrates

Exposure of benthic invertebrates in the ERA will be assessed primarily through the direct toxicity approach. This line of evidence for assessing risks to benthic invertebrates will be considered in the Round 2 Comprehensive Report and in the BERA. Other lines of evidence for assessing risk to benthic invertebrates (i.e., qualitative assessment of epibenthic and infaunal invertebrate community data, sediment profile imaging (SPI) data, and assessment of risks via the groundwater and surface water exposure pathways) also will be presented in the Round 2 Comprehensive Report and the BERA. In the PRE, the exposure of benthic invertebrates (i.e., crayfish and clams) will be estimated by using a tissue-residue approach only (Section 2.2.1).

Tissue residue concentrations for benthic invertebrates will be identified for all COIs. Benthic invertebrate COIs for the PRE are defined as all bioaccumulative chemicals (i.e., dioxins, PCBs, mercury, chlorinated pesticides and certain other organic chemicals) detected in Round 1 whole-body invertebrate tissue. Tissue-residue exposure concentrations will not be assigned to crayfish or clams for other chemicals (non-COIs). Exposure concentrations for crayfish and clams will be represented by the maximum whole-body tissue concentration in crayfish and clams, respectively, reported in the Round 1 data. Table 3-2 and Figure 3-2 present the sampling locations of crayfish and clam whole-body tissue samples that will be used to represent whole-body residue concentrations.

In addition to screening-level exposure estimates, invertebrate tissue-residue exposure concentrations also will be calculated as a 95% UCL assuming lognormal distribution of whole-body tissue data and using Equation 5-1 (EPA 1992). The 95% UCL of the mean whole-body tissue will only be calculated for the tissue concentration for

crayfish. The 95% UCL will not be calculated for whole-body clam tissue because only three composite samples are available.

5.1.2 Exposure Assessment for Fish

In the PRE, exposure of fish will be estimated using two lines of evidence: a whole-body tissue-residue approach and a dietary approach. Chemicals that tend to bioaccumulate in fish (i.e., dioxins, PCBs, mercury, chlorinated pesticides and certain other organic chemicals) will be evaluated using the tissue-residue approach. Chemicals that are metabolized or otherwise regulated by fish (such as PAHs and certain metals) will be evaluated using a dietary approach. Exposure to these chemicals will be expressed as dietary exposure concentrations (i.e., as chemical concentrations in fish prey items and sediment). Parameters that will be used to estimate dietary exposure concentrations for fish are presented in Section 5.2.1.

5.1.2.1 Tissue-Residue Exposure

Tissue-residue exposure concentrations for fish will be represented by the maximum whole-body tissue concentration measured in each ecological fish receptor (i.e., largescale sucker, carp, juvenile chinook salmon, sculpin, peamouth, smallmouth bass, and northern pikeminnow), as reported in the Round 1 data. Table 3-2 and Figure 3-2 present the sampling locations of fish whole-body tissue samples that will be used in the exposure calculation. Tissue-residue exposure concentrations for all fish, with the exception of carp, will be derived for all tissue COIs. In the PRE, fish tissue COIs are defined as all chemicals detected in Round 1 whole-body fish tissue analyses. Carp will be used as a surrogate for other fish species for the evaluation of dioxins and PCB congeners (TEQs are calculated separately for dioxins and PCB congeners; see Section 3.4).

In addition to screening-level exposure estimates, fish tissue-residue exposure concentrations also will be calculated as a 95% UCL assuming lognormal distribution of whole-body tissue data and using Equation 5-1 (EPA 1992). The 95% UCL of the mean whole-body tissue will only be calculated for tissue concentrations when at least six composite samples are available (i.e., the 95% UCL will not be calculated for whole-body peamouth tissue, where only four composite samples are available). A 95% UCL based on a low sample size is generally a poor estimate of the mean, and a sample size of fewer than six was determined to be insufficient for a reasonable estimate of the mean based on best professional judgment. This assumption will be evaluated in the uncertainty section of the PRE.

5.1.2.2 Dietary Exposure

Dietary exposure concentrations for fish will incorporate ingestion of both prey and sediment. The dietary concentration for each ecological fish receptor (i.e., largescale sucker, juvenile chinook salmon, sculpin, peamouth, smallmouth bass, and northern pikeminnow) will be estimated using the following equation:

$$C_{diet} = (C_{prey} \times F_{prey}) + (C_{sed} \times F_{sed}) \qquad \textbf{Equation 5-2}$$

Where:

C_{diet} = estimated concentration in fish diet (mg/kg dry weight [dw])
C_{prey} = maximum whole-body tissue concentration across all prey items identified for fish receptor (mg/kg dw[5])
F_{prey} = percent of the fish receptor diet that is fish and/or invertebrate prey (%)
C_{sed} = maximum concentration in surface sediment (mg/kg dw)
F_{sed} = percent of the fish receptor diet that is sediment (%)

Dietary assumptions that will be used in calculating dietary exposure for fish vary across fish receptors (see Section 5.2 and Table 5-1). The tissue concentration (i.e., C_{prey}) in the dietary exposure calculation for fish will be represented by the maximum whole-body tissue concentration reported in the Round 1 data across all prey items identified for each fish receptor. Table 3-2 and Figure 3-2 present the sampling locations of all whole body tissue samples that will be considered in the dietary exposure calculation. The sediment concentration (C_{sed}) in the dietary exposure calculation for fish will be represented by the maximum surface sediment concentration reported in the Round 1 and/or historical database. Figures 3-1 and 3-4 present the sampling locations of Round 1 and historical surface sediment samples, respectively, that will be used in the dietary exposure calculation.

Proportions of sediment and prey tissue in the total diet are presented in Table 5-1. No data are available on sediment consumption by fish; the dietary proportions of sediment and prey are based on best professional judgment and are uncertain. These percentages (F_{sed} and F_{prey}) will be used in calculating dietary exposure for fish.

In addition to screening-level exposure estimates, fish dietary exposure concentrations will also be calculated using 95% UCLs to represent tissue and sediment concentrations. Tissue and sediment concentrations (C_{sed} and C_{prey}, respectively) used in the dietary exposure concentration calculation will be represented by 95% UCLs, assuming lognormal distribution of whole-body tissue and sediment data and using Equation 5-1 (EPA 1992).

5.1.3 Exposure Assessment for Wildlife

In the PRE, exposure of wildlife (i.e., birds and mammals) will be estimated using a dietary approach that includes ingestion of biota (prey) and incidental ingestion of sediment. A dietary exposure dose will be derived as mg/kg bw/day using exposure parameters (e.g., food ingestion rate [FIR], sediment ingestion rate [SIR], body weight [BW]) presented in Section 5.2.2. Dietary exposure dose for wildlife will

[5] Wet weight invertebrate and fish whole-body tissue concentrations will be converted to dw concentrations using 75% and 73% moisture, respectively. These are the average percent moisture concentrations in fish and invertebrate whole body tissue, respectively, measured in Round 1.

incorporate ingestion of prey and sediment, and the body-weight normalized dose (mg/kg bw/day) will be calculated as follows:

$$IR_{diet} = \frac{\left[\left(FIR \times C_{prey}\right) + \left(FIR \times SI \times C_{sed}\right)\right]}{BW} \times SUF \qquad \textbf{Equation 5-3}$$

Where:

IR_{diet}	=	estimated bird or mammal dietary intake rate (mg/kg bw/day)
FIR	=	daily food ingestion rate (kg dw food/day)
C_{prey}	=	maximum whole-body tissue concentration across all prey items identified for bird or mammal receptor (mg/kg ww)
SI	=	portion of dry diet that is sediment (% of diet, dw)
C_{sed}	=	maximum concentration in surface sediment (mg/kg dw)
BW	=	body weight (kg)
SUF	=	site use factor (unitless); SUF = 1.0 for all receptors in the PRE

Assumptions that will be used in calculations of the dietary exposure dose for birds and mammals vary across wildlife receptor species (see Section 5.2 and Table 5-2). The tissue concentration (C_{prey}) in the dietary exposure dose calculation for wildlife will be represented by the maximum whole-body tissue concentration reported in Round 1 across all prey items identified for each bird or mammal receptor. Table 3-2 and Figure 3-2 present the sampling locations of all whole-body tissue samples that will be considered in the dietary exposure calculation. The sediment concentration (C_{sed}) in the dietary dose calculation for wildlife will be represented by the maximum surface sediment concentration reported in the Round 1 and/or historical database. Figures 3-1 and 3-4 present the sampling locations of surface sediment samples that will be used in the dietary exposure calculation.

Body weights and food and sediment ingestion rates are presented in Table 5-2. Body weights are primarily based on the literature presented in EPA's *Wildlife Exposure Factors Handbook* (EPA 1993), and food ingestion rates are primarily based on the allometric equations presented in Nagy (2001). Sediment ingestion rates were based on Beyer et al. (1994) or best professional judgment, where no data were available. These assumptions (i.e., FIR, SI, and BW) will be used in calculating dietary exposure for wildlife.

In addition to screening-level exposure estimates, wildlife dietary exposure doses will also be calculated using 95% UCLs to represent sediment and tissue concentrations. Sediment and tissue concentrations used in the dietary exposure concentration calculation will be represented by 95% UCLs, assuming lognormal distribution of whole-body tissue and sediment data and using Equation 5-1 (EPA 1992).

5.2 DIETARY EXPOSURE ASSUMPTIONS

Dietary assumptions are defined for fish, birds, and mammals in order to estimate dietary exposure for receptor species within these receptor groups. Exposure estimates in the PRE will be calculated as screening-level exposure estimates. Conservative assumptions are recommended at the screening level (EPA 1997), and conservative dietary assumptions (e.g., 100% site use factor, high sediment ingestion rates) will be used in the PRE to estimate dietary exposure.

5.2.1 Fish Exposure Assumptions

Table 5-1 presents the dietary exposure assumptions that will be used to estimate dietary concentrations for metabolized or otherwise regulated chemicals (i.e., PAHs and all metals except mercury) in the six fish receptors being evaluated via dietary exposure in the PRE (i.e., largescale sucker, juvenile chinook salmon, sculpin, peamouth, smallmouth bass, and northern pikeminnow).

Fish dietary exposure estimates are based on conservative, screening-level assumptions, including ingestion of only prey with the highest tissue contaminant concentration of any single sample of the assumed prey species and only the sediment with the highest sediment contaminant concentration over the entire initial study area (ISA). These exposure estimates provide an upper bound on the actual exposure conditions for fish receptors. Exposure estimates based on more realistic assumptions and exposure point concentrations will be presented in the Round 2 Comprehensive Report and the BERA.

No data were readily available on incidental sediment ingestion by the selected fish receptors. Therefore, conservative estimates of sediment ingestion were determined using best professional judgment by taking into account the feeding modes of each fish receptor species. Also presented in Table 5-1 are the prey species collected in Round 1 that were selected to represent receptor species prey items, including fish species (i.e., largescale sucker, carp, juvenile chinook salmon, sculpin, peamouth, smallmouth bass, northern pikeminnow, black crappie, and brown bullhead) and invertebrate species (i.e., crayfish and clams). The whole-body tissue data for these potential prey items will be used in calculating the dietary concentrations for fish receptors (see Section 5.1.2).

The rationale for these selected dietary assumptions is presented in the following subsections, by receptor species.

5.2.1.1 Largescale Sucker

The largescale sucker prefers to remain close to the bottom in shallow waters, both as a juvenile and as an adult, and is primarily a bottom-feeder. Largescale suckers consume insect larvae as juveniles and diatoms, detritus, crustaceans, and snails as adults (CBFWA 1996). This native fish is known to consume large amounts of

sediment during feeding as an adult (CBFWA 1996). Largescale suckers live in close association with sediment, and benthic invertebrates are a primary component of their diet.

Based on this information, it was conservatively estimated that largescale suckers could ingest up to 50% sediment while feeding. Crayfish and clams are the only invertebrate species with available tissue data collected in Round 1, and these two species will represent the prey items when calculating dietary exposure for largescale suckers.

5.2.1.2 Juvenile Chinook Salmon

Stomach-content analysis of large numbers of juvenile chinook salmon show no evidence of sediment ingestion (Cordell 2001). Therefore, 0% sediment ingestion was assumed for juvenile chinook salmon. Juvenile chinook salmon prey on aquatic insect larvae and terrestrial insects (Healy 1991; Wydoski and Whitney 1979). Juvenile chinook salmon may also prey on zooplankton and epibenthic invertebrates. Crayfish and clams are the only invertebrate species with available tissue data collected in Round 1, and these two species will represent the prey items when calculating dietary exposure for juvenile chinook salmon.

5.2.1.3 Sculpin

Sculpin live in close association with sediments and are primarily benthic feeders. As adults, sculpin can burrow up to 36 cm into gravel to forage (Wydoski and Whitney 1979). It was conservatively estimated that sculpin may incidentally ingest up to 30% sediment while feeding.

Adult sculpin consume crustaceans, aquatic insects, snails, fish, fish eggs, and mollusks, while juvenile sculpin feed on aquatic insect larvae (Wydoski and Whitney 1979). Sculpin are also known to be cannibalistic and may prey on other sculpin. Crayfish and clam whole-body tissue will be used to represent the invertebrate portion of the sculpin diet. Juvenile chinook salmon and other sculpin will be used to represent the fish portion of the sculpin diet. These four species will represent the prey items when calculating dietary exposure for sculpin.

5.2.1.4 Peamouth

Peamouth are a benthopelagic species in that they prey on both benthic and pelagic prey. Adult peamouth predominately feed on benthic invertebrates, crustaceans, and small fish (Wydoski and Whitney 1979). While feeding, peamouth may ingest sediment directly through the mouth or indirectly through prey. However, benthic species comprise only a part of the peamouth diet, and peamouth spend a significant portion of time in the pelagic zone and are not likely to have substantial direct contact with sediment. Therefore, it was estimated that peamouth may incidentally ingest up to 5% sediment while feeding. Crayfish and clams will be used to represent the invertebrate portion of the peamouth diet. Juvenile chinook salmon and sculpin will

be used to represent the fish portion of the peamouth diet. These four species will represent the prey items when calculating dietary exposure for peamouth.

5.2.1.5 Smallmouth Bass

As a benthopelagic species, smallmouth bass consume fish, crayfish and other crustaceans, mollusks, and worms as adults and insect larvae and zooplankton as juveniles (George and Hadley 1979; Turner 1966; Wydoski and Whitney 1979). Smallmouth bass consume benthic prey and may incidentally consume some sediment. Like peamouth, smallmouth bass spend a significant portion of time in the pelagic zone and are not likely to have substantial direct contact with sediment. Therefore, it was estimated that smallmouth bass may incidentally ingest up to 5% sediment while feeding. Sculpin, peamouth, juvenile chinook salmon, crayfish, black crappie, brown bullhead, and other smallmouth bass will be used to represent the smallmouth bass diet. These seven species will represent the prey items when calculating dietary exposure for smallmouth bass.

5.2.1.6 Northern Pikeminnow

Northern pikeminnow is a benthopelagic species. Adult northern pikeminnow consume predominately fish and some insects (Buchanan et al. 1981; Jeppson and Platts 1959). Like smallmouth bass, northern pikeminnow may occasionally come into contact with sediments when foraging, though they are not likely to have substantial direct contact with sediment. Therefore, it was estimated that northern pikeminnow may incidentally ingest up to 5% sediment while feeding. All fish species (i.e., sculpin, peamouth, juvenile chinook salmon, smallmouth bass, largescale sucker, brown bullhead, northern pikeminnow, crayfish, black crappie, and carp) and crayfish collected in Round 1 will represent the prey items when calculating dietary exposure for northern pikeminnow.

5.2.2 Wildlife Exposure Assumptions

Table 5-2 presents the exposure assumptions that will be used to calculate the daily exposure dose for each wildlife receptor, including body weight (BW), FIR, and SI. Also presented in Table 5-2 are the prey species collected in Round 1 that were selected to represent wildlife receptor prey items, including fish species (i.e., largescale sucker, carp, juvenile chinook salmon, sculpin, peamouth, smallmouth bass, northern pikeminnow, black crappie, and brown bullhead) and invertebrate species (i.e., crayfish and clams). The whole-body tissue of these available prey items will be used in calculating the dietary exposure doses for bird and mammal receptors (see Section 5.1.3).

Wildlife dietary exposure estimates are based on conservative, screening-level assumptions, including ingestion of only prey with the highest tissue contaminant concentration of any single sample of the assumed prey species and only sediment with the highest sediment contaminant concentration over the entire ISA. These exposure estimates provide an upper bound on the actual exposure conditions for

wildlife receptors. Exposure estimates based on more realistic assumptions and exposure point concentrations will be presented in the Round 2 Comprehensive Report and the BERA.

5.2.2.1 Spotted Sandpiper

Body Weight and Daily Food Ingestion Rate

Maxson and Oring (1980), as presented in EPA (1993), reported average adult female and male body weights to be 0.0471 and 0.0379 kg, respectively. Daily FIRs were estimated as a function of body weight derived from Nagy (2001). Nagy (2001) reported the body-weight normalized daily FIR for common sandpiper as 0.175 g dw/g bw/day. Using the common sandpiper ingestion rate and the female and male body weights for spotted sandpiper, the calculated FIRs for spotted sandpiper are 0.0082 and 0.0067 kg dw/day, respectively.

Risk based on reproductive endpoints will be assessed by calculating dietary exposure using female exposure values (i.e., body weight and FIR), and risk based on survival and growth endpoints will be assessed by calculating dietary exposure using the average of both male and female exposure values. Exposure calculations for reproductive endpoints will be based on the reported female body weight (0.0471 kg) and the calculated female FIR (0.0082 kg dw/day). Exposure calculations for survival and growth endpoints will be based on the average of male and female body weights (0.0425 kg) and, using that average body weight, a calculated FIR of 0.0074 kg dw/day.

Diet Composition (prey and sediment ingestion)

Spotted sandpipers feed primarily on terrestrial and aquatic insects and may occasionally feed on other benthic macroinvertebrates such as crustaceans, mollusks, and worms (Bent 1929; Csuti et al. 2001). Crayfish and clams are the only invertebrate species with available tissue data and will represent the prey items for dietary exposure calculations for spotted sandpiper. The uncertainty regarding the composition of spotted sandpiper diet and whether these food items adequately represent their diet will be discussed in the uncertainty section of the PRE.

Sediment concentrations may be used to model invertebrate tissue concentrations. Site-specific invertebrate BSAFs may be developed for some chemicals, depending on the correlation between co-located Round 1 sediment and tissue concentrations (see Section 4). For chemicals where no correlation is found between co-located Round 1 sediment and tissue concentrations, BSAFs may be developed from alternate literature sources and databases, where available, and then used to predict invertebrate tissue concentrations from sediment concentrations. The uncertainties and data gaps associated with using BSAFs to model data will be discussed in the uncertainty section of the PRE.

Sandpipers are known to ingest large amounts of sediment while feeding on benthic prey. Beyer et al. (1994) reported that sediment ingestion by four sandpiper species (i.e., stilt sandpiper, semipalmated sandpiper, least sandpiper, and western sandpiper) ranged from 7.3 to 30% of the dry diet, with an average sediment ingestion of 18%. A sediment ingestion rate of 18% will be used to calculate dietary exposure for sandpiper.

5.2.2.2 Hooded Merganser

Body Weight and Daily Food Ingestion Rate

Dunning (1993) reported adult female hooded merganser body weights ranging from 0.54 to 0.68 kg and adult male body weights ranging from 0.68 to 0.91 kg. The daily FIR was estimated as a function of body weight using the following allometric equation developed for carnivorous birds (Nagy 2001):

$$FIR = 0.849 \times BW^{0.663} \qquad \textbf{Equation 5-4}$$

Where:

FIR = daily food ingestion rate (g dw/day)
BW = body weight (g)

Using the lower of the average female and male hooded merganser body weights reported in Dunning (1993; 0.54 and 0.68 kg, respectively), the calculated female and male FIRs are 0.055 and 0.064 kg dw/day, respectively.

Risk based on reproductive endpoints will be assessed by calculating dietary exposure using female exposure values (i.e., body weight and FIR), and risk based on survival and growth endpoints will be assessed by calculating dietary exposure using the average of both male and female exposure values. Exposure calculations for reproductive endpoints will be based on the lower range of female body weight (0.54 kg) and the calculated female FIR (0.055 kg dw/day). Exposure calculations for survival and growth endpoints will be based on the average of the lower range of male and female body weights (0.61 kg) and, using that average body weight, a calculated FIR of 0.060 kg dw/day.

Diet Composition (prey and sediment ingestion)

Hooded mergansers feed primarily by diving for whatever small fish are abundant, but they will also eat aquatic invertebrates, especially as hatchlings (Csuti et al. 2001). They are also known to feed on crustaceans and aquatic insects (Bendell and McNicol 1995). Prey sizes of fish for hooded merganser have been reported to be two inches or less (Alexander 2000). Fish modeled in the hooded merganser diet will be limited to juvenile chinook salmon and sculpin. Sizes of individual sculpin and juvenile chinook salmon caught in Round 1 ranged from 3.6 to 6.8 inches and 3.4 and 4.7 inches, respectively. The Round 1 data will be used to represent the fish portion of the hooded merganser diet even though these individuals are larger than the report preferred prey size (i.e., two inches or less). The benthic invertebrate portion of the

modeled merganser diet will be represented by clam and crayfish tissue. These four species (juvenile chinook salmon, sculpin, clam, and crayfish) will represent the prey items when calculating the dietary exposure dose for hooded merganser.

Hooded mergansers are likely to ingest a small amount of sediment incidentally while foraging and indirectly through their prey. An incidental sediment ingestion rate of 2% will be used when calculating dietary exposure for hooded mergansers, based on best professional judgment.

5.2.2.3 Bald Eagle

Body Weight and Daily Food Ingestion Rate

Wiemeyer (1991), as cited in EPA (1993), reported average adult female and male body weights for bald eagles to be 4.5 and 3.0 kg, respectively. The FIR will be represented as 12% of the body weight on a wet weight basis, based on studies by Stalmaster and Gessaman (1982), as presented in EPA (1993), of free-flying eagles in Washington. Using the average female and male bald eagle body weights, the calculated FIR rates were 0.54 and 0.36 kg ww/day, respectively. FIRs were converted to dry weight using the average measured moisture content (73%) for fish collected in Round 1 sampling, resulting in female and male bald eagle FIRs of 0.146 and 0.097 kg dw/day, respectively.

Risk based on reproductive endpoints will be assessed by calculating dietary exposure using female exposure values (i.e., body weight and FIR), and risk based on survival and growth endpoints will be assessed by calculating dietary exposure using the average of both male and female exposure values. Exposure calculations for reproductive endpoints will be based on the reported female body weight (4.5 kg) and the calculated female FIR (0.146 kg dw/day). Exposure calculations for survival and growth endpoints will be based on the average of the male and female body weights (3.75 kg) and the average of the male and female FIRs (0.122 kg dw/day).

Diet Composition (prey and sediment ingestion)

Bald eagles are opportunistic foragers with site-specific food habits based on available prey species (Anthony et al. 1999; Buehler 2000). Eagles consume dead and live fish, birds, and occasionally mammals. In most regions, bald eagles seek out aquatic habitats for foraging and prefer fish (Buehler 2000; Ehrlich et al. 1988). In one study conducted in the lower Columbia River estuary, diet composition of bald eagles based on direct observation was 90% fish, 7% birds, and 3% mammals (Watson et al. 1991). The bald eagle diet will be modeled using 100% of prey items from fish species. Any of the fish species collected in Round 1 sampling may be consumed by bald eagles, so all fish tissue data (i.e., carp, largescale sucker, juvenile chinook salmon, sculpin, peamouth, brown bullhead, black crappie, northern pikeminnow, and smallmouth bass) will represent the prey items when calculating the dietary exposure dose for bald eagles.

Data on sediment ingestion rates were not available for bald eagles, but it is likely that bald eagles consume a small amount of sediment while scavenging along the shoreline. An incidental sediment ingestion rate of 2% will be used when calculating the dietary exposure for bald eagles, based on best professional judgment.

5.2.2.4 Osprey

Body Weight and Daily Food Ingestion Rate

Brown and Amadon (1986), as presented in EPA (1993), reported average adult female and male osprey body weights to be 1.57 and 1.4 kg, respectively. The daily FIR was estimated as a function of body weight using the allometric equation developed for carnivorous birds (Nagy 2001). Using the average female and male osprey body weights, the calculated FIRs are 0.112 and 0.103 kg dw/day, respectively.

Risk based on reproductive endpoints will be assessed by calculating dietary exposure using female exposure values (i.e., body weight and FIR), and risk based on survival and growth endpoints will be assessed by calculating dietary exposure using the average of both male and female exposure values. Exposure calculations for reproductive endpoints will be based on the reported female body weight (1.57 kg) and the calculated female FIR (0.112 kg dw/day). Exposure calculations for survival and growth endpoints will be based on the average of the male and female body weights (1.49 kg) and, using that average body weight, a calculated FIR of 0.108 kg dw/day.

Diet Composition (prey and sediment ingestion)

Osprey tend to feed solely on fish, primarily on slow-moving fish that swim near the water surface (Csuti et al. 2001). The osprey diet will be modeled using 100% of prey items from fish species. Any of the fish species collected in Round 1 may be consumed by osprey, so all fish tissue data (i.e., carp, largescale sucker, juvenile chinook salmon, sculpin, peamouth, brown bullhead, black crappie, northern pikeminnow, and smallmouth bass) will represent the prey items when calculating the dietary exposure dose for osprey.

Data on osprey sediment ingestion were not available, but osprey may consume a small amount of sediment while scavenging along the shoreline (which occurs very rarely). Therefore, a sediment ingestion of 2% of the dry diet will be assumed for calculating the dietary exposure for osprey.

5.2.2.5 Mink

Body Weight and Daily Food Ingestion Rate

Mitchell (1961), as presented in EPA (1993), reported average adult female and male body weights for mink in the summer to be 0.55 and 1.04 kg, respectively. The daily FIR was estimated as a function of body weight using the following equation developed for carnivores (Nagy 2001):

$$FIR = 0.102 \times BW^{0.864}$$ **Equation 5-5**

Where:

FIR = daily food ingestion rate (g dw/day)
BW = body weight (g)

Using the average female and male mink body weights, the calculated FIRs were 0.0238 and 0.0412 kg dw/day, respectively.

Risk based on reproductive endpoints will be assessed by calculating dietary exposure using female exposure values (i.e., body weight and FIR), and risk based on survival and growth endpoints will be assessed by calculating dietary exposure using the average of both male and female exposure values. Exposure calculations for reproductive endpoints will be based on the average female body weight (0.55 kg) and the calculated female FIR (0.0238 kg dw/day). Exposure calculations for survival and growth endpoints will be based on the average of the male and female body weights (0.795 kg) and, using that average body weight, a calculated FIR of 0.0327 kg dw/day.

Diet Composition (prey and sediment ingestion)
Mink are opportunistic feeders and consume a range of prey including muskrats, fish, frogs, crayfish, small mammals, and birds found near water (Csuti et al. 2001). All fish species (i.e., sculpin, peamouth, juvenile chinook salmon, smallmouth bass, largescale sucker, brown bullhead, northern pikeminnow, black crappie, and carp) and invertebrate species (i.e., crayfish and clam) collected in Round 1 will represent the prey items when calculating the dietary exposure dose for mink.

Data were not available on the amount of sediment consumed by mink while feeding. Beyer et al. (1994), as presented in EPA (1993), reported a sediment ingestion of 9.4% of the dry diet for raccoons. This sediment ingestion rate will be used to calculate a dietary exposure dose for mink.

5.2.2.6 River Otter

Body Weight and Daily Food Ingestion Rate
Melquist and Hornnocker (1983), as presented in EPA (1993), reported average adult female and male river otter body weights to be 7.9 and 9.2 kg, respectively. The daily FIR for river otter was estimated as a function of body weight using the allometric equation developed for carnivorous mammals (Nagy 2001). Using the average female and male river otter body weights, the calculated FIRs were 0.238 and 0.271 kg dw/day, respectively.

Risk based on reproductive endpoints will be assessed by calculating dietary exposure using female exposure values (i.e., body weight and FIR), and risk based on survival and growth endpoints will be assessed by calculating dietary exposure using the average of both male and female exposure values. Exposure calculations for

reproductive endpoints will be based on the average female body weight (7.9 kg) and the calculated female FIR (0.238 kg dw/day). Exposure calculations for survival and growth endpoints will be based on the average of the male and female body weights (8.55 kg) and, using that average body weight, a calculated FIR of 0.256 kg dw/day.

Diet Composition (prey and sediment ingestion)

River otters are opportunistic carnivores that take advantage of food that is most abundant and easiest to catch, although fish are their primary prey (EPA 1993). Other components of the river otter's diet may include aquatic invertebrates (including crayfish, mussels, clams, and aquatic insects), frogs, snakes, turtles, and occasionally scavenged small mammals and birds (Coulter et al. 1984; Csuti et al. 2001). River otters catch fish by diving and ambushing or chasing, and will dig in the substrate for invertebrates (Coulter et al. 1984). All fish species (i.e., sculpin, peamouth, juvenile chinook salmon, smallmouth bass, largescale sucker, brown bullhead, northern pikeminnow, black crappie, and carp) and invertebrate species (i.e., crayfish and clam) collected in Round 1 will be used to represent the prey items when calculating the dietary exposure dose for river otter.

No data are available concerning sediment ingestion for the river otter. River otters may ingest a small amount of sediment incidentally while foraging and indirectly through their prey. Therefore, an estimated sediment ingestion rate of 2% of the dry diet will be used when calculating the dietary exposure dose for river otter.

6.0 CHARACTERIZATION OF EFFECTS

Ecological effects characterization evaluates the evidence that exposure to stressors (i.e., chemical exposure) causes an observed response (EPA 1998). Effects will be represented in the PRE by effect concentrations (i.e., TRVs). TRVs have been selected from available toxicological literature and represent threshold concentrations at which adverse effects to survival, growth, or reproduction may occur. The selection of appropriate TRVs for benthic invertebrates, fish, and wildlife is described in the TRV selection technical memorandum (Windward 2004) submitted to EPA on April 28, 2004. This technical memorandum describes the process of selecting TRVs for use in the Portland Harbor ERA and presents selected TRVs for benthic invertebrates (based on a tissue-residue approach), fish, and wildlife. Final TRVs that will be used in the PRE and throughout the ERA will be agreed upon by LWG and EPA and its partners.

TRVs for benthic invertebrates and fish were derived for both the no-observed-effect concentration and lowest-observed-effect concentration (NOECs and LOECs, respectively). TRVs for mammals were derived for both the no-observed-adverse-effect level (NOAEL, the highest dose at which no adverse effect was observed) and lowest-observed-adverse-effect level (LOAEL, the lowest dose at which an adverse effect was observed). The PRE will consider both NOECs/NOAELs and LOECs/LOAELs.

6.1 BENTHIC INVERTEBRATES

TRVs were developed for crayfish and clams, where literature was available, in the TRV selection technical memorandum. TRVs for the Portland Harbor ERA were derived for both NOECs and LOECs using critical whole-body tissue residue TRVs, where data were available.

6.2 FISH

TRVs were developed for fish, where literature was available, in the TRV selection technical memorandum, using both NOECs and LOECs. TRVs for fish were developed using two different approaches, depending on the analyte. For bioaccumulative chemicals, whole-body tissue-residue TRVs were derived. For chemicals that are metabolized or otherwise regulated by the fish (such as PAHs and certain metals), a tissue-residue approach is not appropriate (McCarty and MacKay 1993). Instead, TRVs (i.e., NOECs and LOECs) were derived based on the dietary concentrations of these chemicals associated with effects in fish.

6.3 WILDLIFE

TRVs were developed for birds and mammals, where literature was available, in the TRV selection technical memorandum. TRVs for the Portland Harbor ERA were derived for both NOAELs and LOAELs.

7.0 PRELIMINARY RISK CHARACTERIZATION: INITIAL IDENTIFICATION OF COPCS

The risk estimation is the process of integrating exposure and effects (EPA 1998). In the PRE, preliminary risks will be estimated using a hazard quotient (HQ) approach. The approach of comparing exposure concentrations to effect concentrations in a quotient is recommended by EPA guidance (1998). The HQ approach and the methods for identifying the initial list of COPCs are presented in the following subsections.

7.1 HAZARD QUOTIENT APPROACH

Hazard quotients will be calculated in the PRE for benthic invertebrates, fish, and wildlife. The HQ will be calculated as the ratio of the exposure concentration to the effects concentration (i.e., NOEC/NOAEL and LOEC/LOAEL TRV) for each chemical where data are available:

$$HQ = \frac{EEC}{TRV} \qquad \textbf{Equation 7-1}$$

Where:

HQ = ecological hazard quotient (unitless)
EEC = estimated exposure concentration (whole-body or dietary)
TRV = toxicity reference value (whole-body tissue-residue or dietary)

COIs resulting in HQs greater than one (i.e., where exposure is greater than levels at which no adverse effects are observed [i.e., NOECs and NOAELs] or at which adverse effects are observed [i.e., LOECs and LOAELs]) identify COPCs for selected receptors, which will be further evaluated in the ERA. However, HQs that exceed one and are calculated based on preliminary exposure estimates do not necessarily indicate unacceptable or actionable risk estimates, but that additional risk analysis is needed to support risk management decisions. This is especially true for screening-level exposure and risk estimates such as to be calculated in the PRE.

7.2 IDENTIFICATION OF INITIAL COPCS

Fish and wildlife COI/receptor pairs with screening-level HQs less than 1 will not be considered part of the initial COPC list for the Portland Harbor Superfund Site. These COIs likely pose negligible risk to fish and/or wildlife receptor species. Fish and wildlife COI/receptor pairs with screening-level HQs greater than 1 will be identified as initial COPCs. This initial list of COPC/receptor pairs will be refined or expanded based on the results of the Round 2 sampling and analysis. For benthic invertebrates (i.e., clams and crayfish), initial COPCs will be identified based on the tissue-residue approach; however, this line of evidence will likely have limited utility in the overall

risk assessment for benthic invertebrates because of the limited tissue data (from crayfish and clams only) and limited tissue-residue based effects data. Assessment of risk to benthic invertebrates will be based on multiple lines of evidence and will be discussed in the Round 2 Comprehensive Report and BERA.

7.3 ADDITIONAL EXPOSURE CALCULATIONS

Exposure estimates using 95% UCLs to represent sediment and tissue exposure point concentrations (see Section 5.0) will be presented in the PRE, and HQs will be calculated for these exposure estimates. These results will be presented for discussion purposes only to provide exposure estimates that may more accurately reflect actual exposure concentrations and will not be used to limit the initial COPC list based on the screening-level assessment (Section 7.2). The limitations of these exposure estimates (e.g., they do not consider the spatial distribution of sediment concentrations; they assume lognormally distributed data) will be discussed in the uncertainty section of the PRE. The Round 2 Comprehensive Report and BERA will provide a detailed analysis of the data distribution to determine which statistics are most appropriate to derive tissue and sediment exposure point concentrations.

8.0 UNCERTAINTY ASSOCIATED WITH THE PRE

The uncertainty associated with the initial risk characterization presented in the PRE will be discussed in an uncertainty section of the PRE. The uncertainty section of the PRE may discuss, but is not limited to, the following uncertainties:

- Use of clam and crayfish tissue data to model invertebrate concentrations in diet for ecological receptors (e.g., spotted sandpiper, hooded merganser, largescale sucker, and juvenile chinook salmon)
- Use of Round 1 surface sediment data to characterize dietary exposure (where few samples [n=58] are available)
- Use of historical surface sediment data to characterize dietary exposure (sampling design methods, sample collection methods, and laboratory analyses are variable across sampling events, and high detection limits (DLs) were reported for some analytes)
- Use of clam tissue data (where few data [n=3] are available)
- Use of maximum tissue concentrations in any prey species and/or maximum sediment concentrations anywhere in the Portland Harbor Superfund Site for exposure concentration estimates
- Use of 1.0 as the site use factor for all wildlife receptors (i.e., assuming they never leave Portland Harbor)
- Availability of species used to represent prey tissue concentrations (e.g., use of crayfish and clams to represent all invertebrate prey)
- Application of BSAFs to predict tissue concentrations
- Identification of COPCs for benthic invertebrates using a minor line of evidence (tissue-residue approach) and limited effects data
- Assumptions used in 95% UCL calculations for tissue and sediment exposure point concentrations (e.g., number of samples used in 95% UCL calculations, data distribution, and spatial distribution of sediment concentration)
- Use of both LOECs/LOAELs and NOECs/NOAELs to identify the initial COPC list (exceedance of a NOEC or NOAEL TRV may not necessarily indicate an adverse effect, whereas exceedance of a LOEC or LOAEL TRV indicates that adverse effects have been observed in experimental studies above that concentration

9.0 DATA AND/OR INFORMATION GAPS

The preliminary risk estimates in the PRE and the associated discussion of uncertainties will help to identify data and information gaps that may be filled during subsequent investigations/evaluations prior to the BERA (e.g., Round 2 and any subsequent rounds of sampling). Additional sampling for the ERA has been proposed in the Round 2 Field Sampling Plan for Sediment Sampling and Benthic Toxicity Testing (Integral and Windward 2004), Shorebird Area and Beach Sampling FSP (Integral et al. 2004b), and Surface Water Sampling FSP (Integral 2004). Round 2 sampling will include the collection of 525 additional surface sediment samples, of which 223 samples will be used for toxicity testing. In addition, 26 beach surface sediment samples will be collected for shorebird (i.e., sandpiper) exposure characterization, and 23 surface water samples also will be collected. These Round 2 data will be used to further characterize risks to benthic invertebrates, fish, and wildlife, and to characterize risks to plants and amphibians/reptiles in the Round 2 Comprehensive Report. If additional data gaps are identified in the Round 2 Comprehensive Report, Round 3 sampling will be proposed to fill these data gaps. The BERA will present the final risk characterization for all ecological receptor groups following the final round of sampling in the Portland Harbor Superfund Site.

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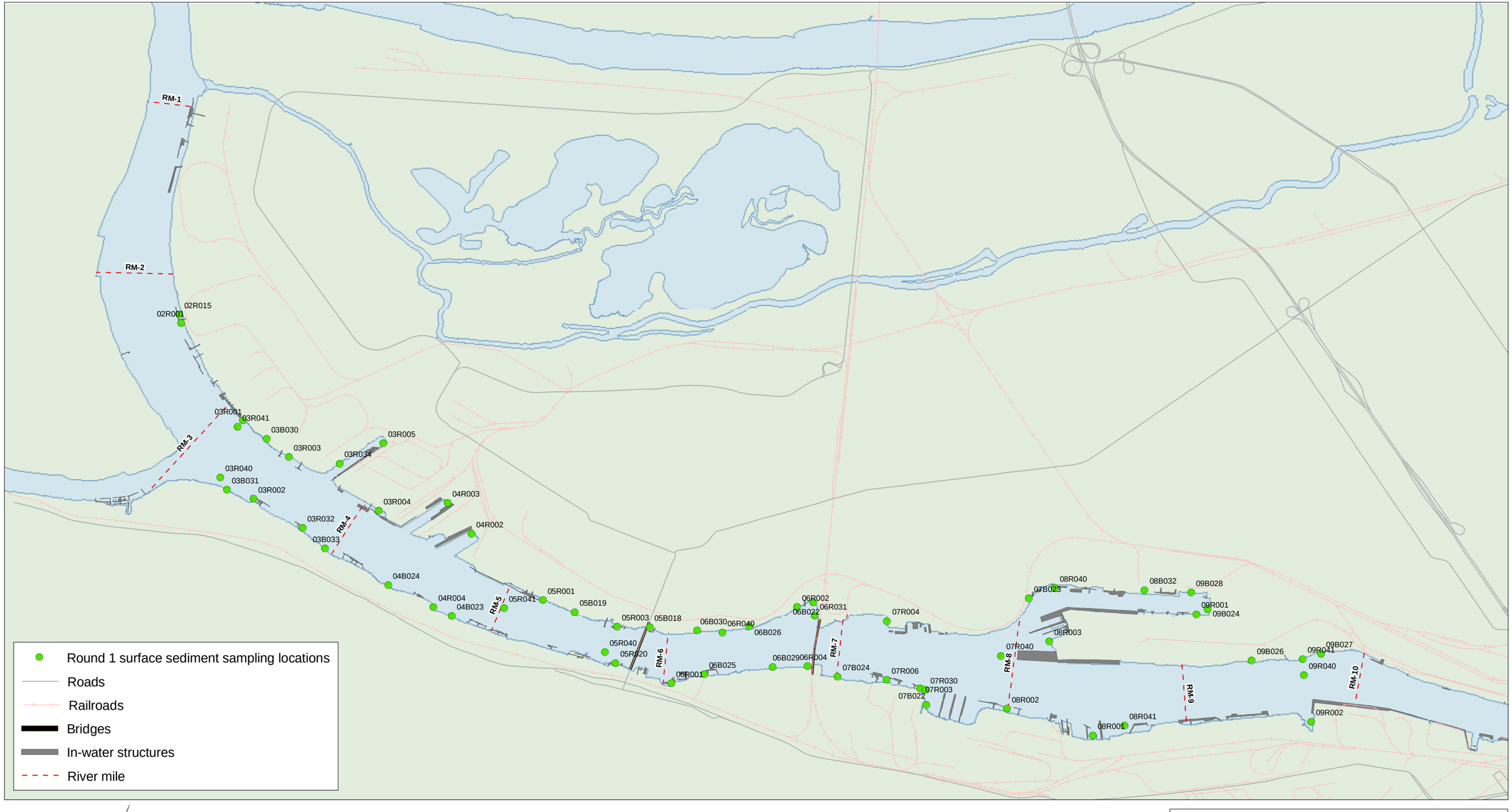
FIGURES



- Round 1 surface sediment sampling locations
- Roads
- Railroads
- Bridges
- In-water structures
- River mile

Wind Ward environmental LLC

0 1,200 2,400 4,800 Feet

0 370 740 1,480 Meters

N

Figure 3-1. Round 1 surface sediment sampling locations

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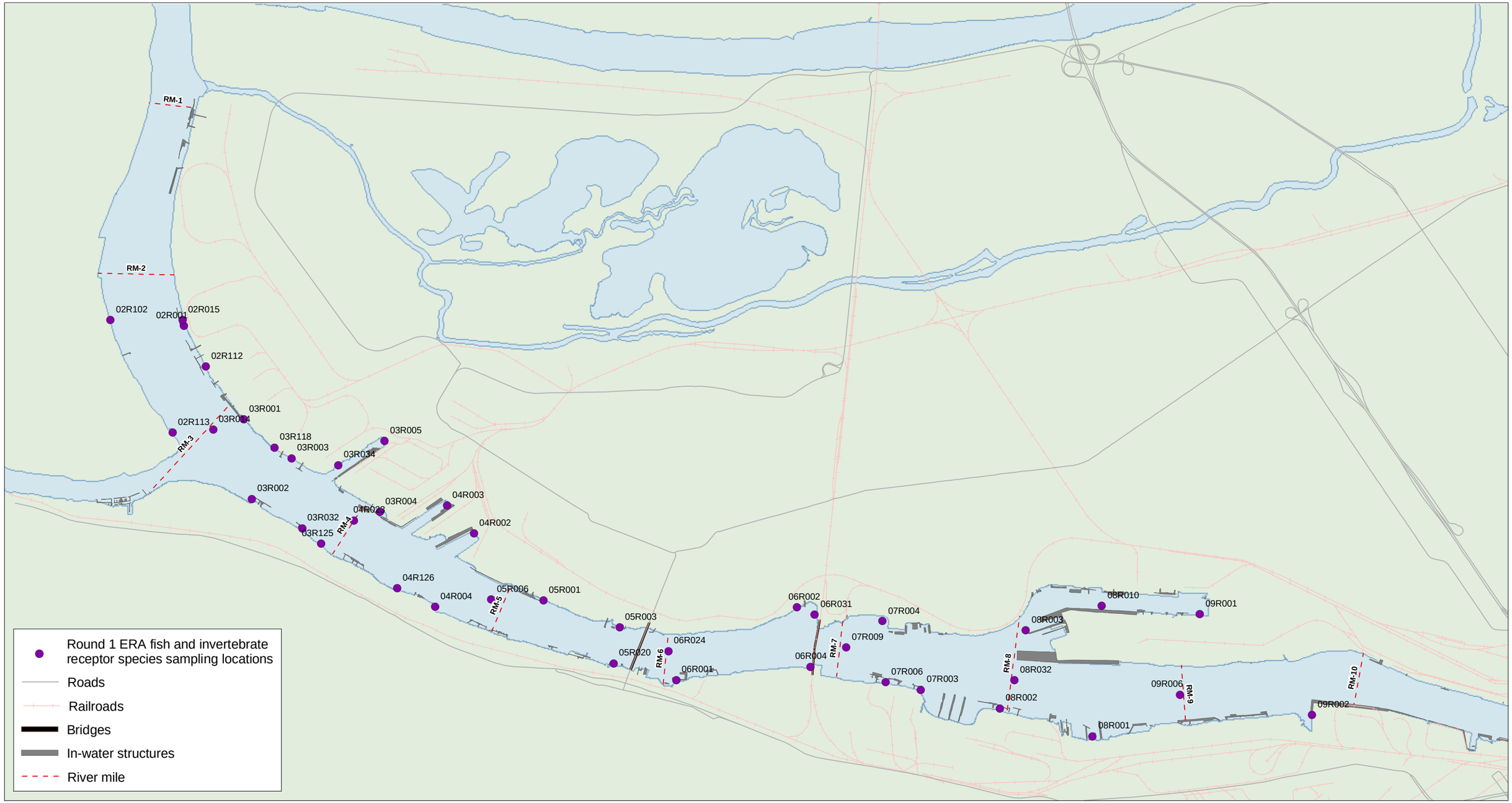

Wind Ward environmental LLC

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Figure 3-2. Round 1 whole-body tissue sampling locations for ERA fish and invertebrate receptors

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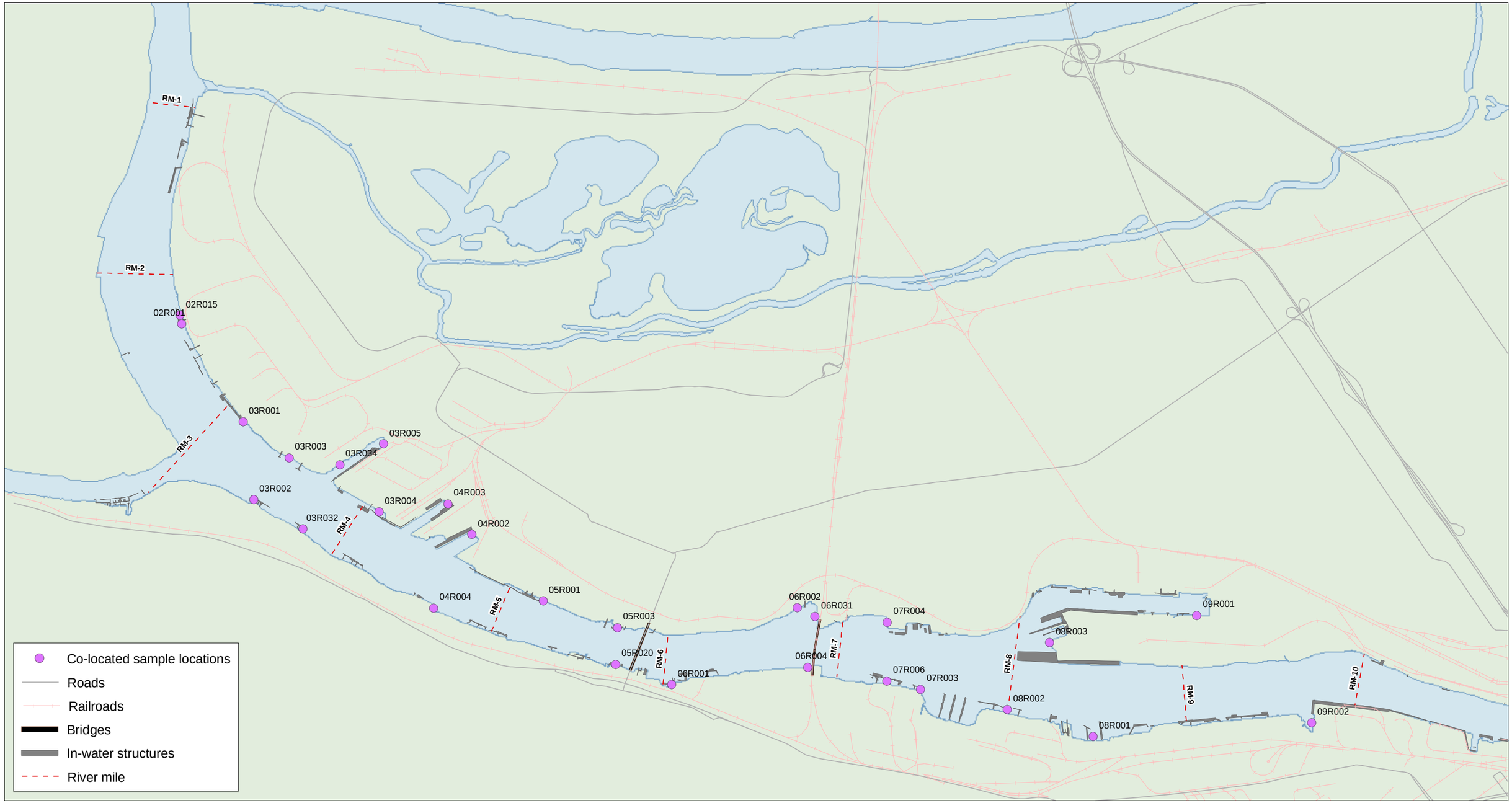

Wind Ward environmental LLC

0 1,200 2,400 4,800 Feet

0 370 740 1,480 Meters

N

Figure 3-3. Round 1 Co-located sediment and tissue sampling locations

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RM-1
RM-2
RM-3
RM-4
RM-5
RM-6
RM-7
RM-8
RM-9
RM-10

Historical (Category 1) surface sediment sampling locations (RM 2.0-9.2)
ISA boundary
Roads
Railroads
Bridges
In-water structures
River mile

Wind Ward environmental LLC

0 1,200 2,400 4,800 Feet
0 370 740 1,480 Meters

N

Figure 3-4. Historical (Category 1) surface sediment sampling locations between RM 2.0 and 9.2

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Prepared by CEJ 05-04-04 Map 1335

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TABLES

Table 3-1 Summary of Round 1 and historical (Category 1 only) surface sediment samples collected at the Portland Harbor Superfund Site

ANALYTE GROUP	ANALYTE	NO. OF ROUND 1 SAMPLES[a]	NO. OF HISTORICAL SAMPLES[b]
Dioxins and furans	Dioxins and furans	9	35
PCB Congeners	PCB Congeners	9	na
PCB Aroclors	Aroclor 1016	58	291
PCB Aroclors	Aroclor 1221	58	290
PCB Aroclors	Aroclor 1232	58	290
PCB Aroclors	Aroclor 1242	58	291
PCB Aroclors	Aroclor 1248	58	291
PCB Aroclors	Aroclor 1254	58	291
PCB Aroclors	Aroclor 1260	58	291
PCB Aroclors	Total PCBs	58	292
Metals	Aluminum	58	195
Metals	Antimony	21	390
Metals	Arsenic	58	517
Metals	Barium	na	206
Metals	Beryllium	na	238
Metals	Butyltin ion	na	134
Metals	Cadmium	58	470
Metals	Chromium	58	502
Metals	Copper	58	517
Metals	Dibutyltin	na	131
Metals	Dibutyltin ion	na	3
Metals	Dibutyltin dichloride	2	na
Metals	Iron	na	208
Metals	Lead	58	559
Metals	Magnesium	na	195
Metals	Manganese	na	208
Metals	Mercury	58	470
Metals	Monobutyltin trichloride	1	na
Metals	Nickel	58	486
Metals	Potassium	na	195
Metals	Selenium	58	249
Metals	Silver	58	470
Metals	Tetrabutyltin	3	115
Metals	Tributyltin chloride	3	na
Metals	Tributyltin ion	3	na
Metals	Thallium	na	238
Metals	Tin	na	13
Metals	Titanium	na	100

Table 3-1 Summary of Round 1 and historical (Category 1 only) surface sediment samples collected at the Portland Harbor Superfund Site

ANALYTE GROUP	ANALYTE	NO. OF ROUND 1 SAMPLES[a]	NO. OF HISTORICAL SAMPLES[b]
Metals	Vanadium	na	195
Metals	Zinc	58	497
PAHs	2-Methylnaphthalene	58	476
PAHs	Acenaphthene	58	661
PAHs	Acenaphthylene	58	661
PAHs	Anthracene	58	661
PAHs	Benzo(a)anthracene	58	661
PAHs	Benzo(a)pyrene	58	661
PAHs	Benzo(b)fluoranthene	58	647
PAHs	Benzo(b+k)fluoranthene	na	658
PAHs	Benzo(g,h,i)perylene	58	661
PAHs	Benzo(k)fluoranthene	58	647
PAHs	Carbazole	58	241
PAHs	Chrysene	58	661
PAHs	Dibenz(a,h)anthracene	58	661
PAHs	Dibenzofuran	58	538
PAHs	Fluoranthene	58	672
PAHs	Fluorene	58	661
PAHs	HPAH	58	672
PAHs	Indeno(1,2,3-cd)pyrene	58	661
PAHs	LPAH	58	663
PAHs	Naphthalene	58	663
PAHs	Phenanthrene	58	661
PAHs	Pyrene	58	661
PAHs	Total PAHs	58	674
Herbicides	2,4,5-T	58	16
Herbicides	2,4-D	58	16
Herbicides	2,4-DB	58	16
Herbicides	Dalapon	58	16
Herbicides	Dicamba	58	16
Herbicides	Dichloroprop	58	16
Herbicides	Dinoseb	58	16
Herbicides	MCPA	58	16
Herbicides	MCPP	58	16
Herbicides	Pentachlorophenol	58	520
Herbicides	Silvex	58	16
Pesticides	2,4'-DDD	57	na
Pesticides	2,4'-DDE	56	na
Pesticides	2,4'-DDT	57	na

Table 3-1 Summary of Round 1 and historical (Category 1 only) surface sediment samples collected at the Portland Harbor Superfund Site

ANALYTE GROUP	ANALYTE	NO. OF ROUND 1 SAMPLES[a]	NO. OF HISTORICAL SAMPLES[b]
Pesticides	4,4'-DDD	58	252
Pesticides	4,4'-DDE	56	251
Pesticides	4,4'-DDT	57	252
Pesticides	Aldrin	57	251
Pesticides	alpha-Chlordane	57	145
Pesticides	alpha-Endosulfan	57	221
Pesticides	alpha-Hexachlorocyclohexane	57	212
Pesticides	beta-Endosulfan	57	238
Pesticides	beta-Hexachlorocyclohexane	57	238
Pesticides	Chlordane (cis & trans)	na	115
Pesticides	Chlordane (technical)	na	139
Pesticides	cis-Nonachlor	56	na
Pesticides	DDD Sum	58	252
Pesticides	DDE Sum	56	251
Pesticides	DDT Sum	57	252
Pesticides	delta-Hexachlorocyclohexane	57	238
Pesticides	Dieldrin	57	251
Pesticides	Endosulfan	na	17
Pesticides	Endosulfan sulfate	56	238
Pesticides	Endrin	57	238
Pesticides	Endrin aldehyde	57	238
Pesticides	Endrin ketone	57	141
Pesticides	gamma-Hexachlorocyclohexane	57	251
Pesticides	Heptachlor	57	251
Pesticides	Heptachlor epoxide	57	238
Pesticides	Hexachlorobenzene	58	359
Pesticides	Hexachlorobutadiene	58	369
Pesticides	Hexachlorocyclopentadiene	58	257
Pesticides	Hexachloroethane	58	297
Pesticides	Methoxychlor	57	238
Pesticides	Mirex	57	na
Pesticides	Oxychlordane	57	na
Pesticides	Total DDTs	58	252
Pesticides	Toxaphene	56	238
Pesticides	trans-Chlordane	57	na
Pesticides	trans-Nonachlor	56	na
Phenols	2,3,4,5-Tetrachlorophenol	58	na
Phenols	2,3,4,6-Tetrachlorophenol	58	na
Phenols	2,3,5,6-Tetrachlorophenol	58	na

Table 3-1 Summary of Round 1 and historical (Category 1 only) surface sediment samples collected at the Portland Harbor Superfund Site

ANALYTE GROUP	ANALYTE	NO. OF ROUND 1 SAMPLES[a]	NO. OF HISTORICAL SAMPLES[b]
Phenols	2,4,5-Trichlorophenol	58	368
Phenols	2,4,6-Trichlorophenol	58	368
Phenols	2,4-Dichlorophenol	58	368
Phenols	2,4-Dimethylphenol	58	465
Phenols	2,4-Dinitrophenol	58	333
Phenols	2-Chlorophenol	58	368
Phenols	2-Methylphenol	58	465
Phenols	2-Nitrophenol	58	342
Phenols	4,6-Dinitro-2-methylphenol	58	367
Phenols	4-Chloro-3-methylphenol	58	368
Phenols	4-Methylphenol	58	393
Phenols	4-Nitrophenol	58	363
Phenols	Phenol	58	465
Phenols	Phenols	na	3
Phenols	Tetrachlorophenol	na	3
Phthalates	1,2,4-Trichlorobenzene	58	307
Phthalates	1,2-Dichlorobenzene	58	383
Phthalates	1,3-Dichlorobenzene	58	383
Phthalates	1,4-Dichlorobenzene	58	383
Phthalates	2,4-Dinitrotoluene	58	276
Phthalates	4-Chloroaniline	58	276
Phthalates	Bis(2-chloroisopropyl) ether	na	19
Phthalates	Bis(2-ethylhexyl) phthalate	58	475
Phthalates	Butylbenzylphthalate	58	475
Phthalates	Dibutyl phthalate	58	474
Phthalates	Diethyl phthalate	58	475
Phthalates	Dimethylphthalate	58	475
Phthalates	Di-n-octyl phthalate	58	475
Phthalates	Nitrobenzene	58	276
SVOCs	1,3-Dichloropropene	na	14
SVOCs	2,6-Dinitrotoluene	58	276
SVOCs	2-Chloronaphthalene	58	276
SVOCs	2-Nitroaniline	58	276
SVOCs	3- and 4-Methylphenol coelution	na	58
SVOCs	3,3'-Dichlorobenzidine	58	276
SVOCs	3-Nitroaniline	58	276
SVOCs	4-Bromophenyl phenyl ether	58	276
SVOCs	4-Chlorophenyl phenyl ether	58	276

Table 3-1 Summary of Round 1 and historical (Category 1 only) surface sediment samples collected at the Portland Harbor Superfund Site

ANALYTE GROUP	ANALYTE	NO. OF ROUND 1 SAMPLES[a]	NO. OF HISTORICAL SAMPLES[b]
SVOCs	4-Nitroaniline	58	276
SVOCs	Aniline	58	24
SVOCs	Benzoic Acid	58	352
SVOCs	Benzyl Alcohol	58	359
SVOCs	Bis(2-chloro-1-methylethyl) ether	58	257
SVOCs	Bis(2-chloroethoxy) methane	58	276
SVOCs	Bis(2-Chloroethyl) Ether	58	276
SVOCs	Isophorone	58	276
SVOCs	N-Nitrosodimethylamine	58	15
SVOCs	N-Nitroso-di-N-propylamine	na	276
SVOCs	N-Nitrosodiphenylamine	58	359
SVOCs	N-Nitrosodipropylamine	58	na
VOCs	1,1,1,2-Tetrachloroethane	1	36
VOCs	1,1,1-Trichloroethane	1	54
VOCs	1,1,2,2-Tetrachloroethane	1	54
VOCs	1,1,2-Trichloro-1,2,2-trifluoroethane	1	na
VOCs	1,1,2-Trichloroethane	1	54
VOCs	1,1-Dichloroethane	1	54
VOCs	1,1-Dichloropropene	1	36
VOCs	1,2,3-Trichlorobenzene	1	36
VOCs	1,2,3-Trichloropropane	1	36
VOCs	1,2-Dibromo-3-chloropropane	1	36
VOCs	1,2-Dichloroethane	1	54
VOCs	1,2-Dichloroethene	na	14
VOCs	1,2-Dichloropropane	1	54
VOCs	1,3,5-Trimethylbenzene	1	36
VOCs	1,3-Dichloropropane	1	36
VOCs	1,4-Dichloro-trans-2-butene	1	na
VOCs	2,2-Dichloropropane	1	36
VOCs	2-Chloroethyl vinyl ether	1	12
VOCs	2-Chlorotoluene	1	36
VOCs	4-Chlorotoluene	1	36
VOCs	Acetone	1	25
VOCs	Ammonia	na	68
VOCs	Acrolein	1	na
VOCs	Acrylonitrile	1	na
VOCs	Azobenzene	58	na

Table 3-1 Summary of Round 1 and historical (Category 1 only) surface sediment samples collected at the Portland Harbor Superfund Site

ANALYTE GROUP	ANALYTE	NO. OF ROUND 1 SAMPLES[a]	NO. OF HISTORICAL SAMPLES[b]
VOCs	Benzene	1	146
VOCs	Benzidine	na	9
VOCs	Bromobenzene	1	36
VOCs	Bromochloromethane	1	36
VOCs	Bromodichloromethane	1	54
VOCs	Bromoethane	1	na
VOCs	Bromoform	1	54
VOCs	Bromomethane	1	54
VOCs	Butylbenzene	na	8
VOCs	Carbon disulfide	1	51
VOCs	Carbon tetrachloride	1	54
VOCs	Chlorobenzene	1	54
VOCs	Chlorodibromomethane	1	54
VOCs	Chloroethane	1	54
VOCs	Chloroform	1	54
VOCs	Chloromethane	1	54
VOCs	cis-1,2-Dichloroethene	1	40
VOCs	cis-1,3-Dichloropropene	1	40
VOCs	Cobalt	na	195
VOCs	Cyanide	na	27
VOCs	Cymene	na	34
VOCs	Dichlorodifluoromethane	1	36
VOCs	Ethylbenzene	1	176
VOCs	Ethylene dibromide	1	36
VOCs	Hexachlorocyclohexanes	na	26
VOCs	Isopropylbenzene	1	36
VOCs	m,p-Xylene	1	na
VOCs	Methyl iodide	1	na
VOCs	Methyl isobutyl ketone	1	28
VOCs	Methyl N-butyl ketone	1	54
VOCs	Methyl tert-butyl ether	1	na
VOCs	Methylene bromide	1	36
VOCs	Methylene chloride	1	54
VOCs	Methylethyl ketone	1	28
VOCs	Naphtha distillate	na	2
VOCs	n-Butylbenzene	1	28
VOCs	n-Propylbenzene	1	36
VOCs	o-Xylene	1	103
VOCs	p-Cymene	1	2

Table 3-1 Summary of Round 1 and historical (Category 1 only) surface sediment samples collected at the Portland Harbor Superfund Site

ANALYTE GROUP	ANALYTE	NO. OF ROUND 1 SAMPLES[a]	NO. OF HISTORICAL SAMPLES[b]
VOCs	Pencil pitch	na	60
VOCs	Phytane	na	47
VOCs	Pristane	na	47
VOCs	Pseudocumene	1	36
VOCs	Sec-butylbenzene	1	33
VOCs	Styrene	1	54
VOCs	tert-Butylbenzene	1	33
VOCs	Tetrachloroethene	1	134
VOCs	Toluene	1	146
VOCs	trans-1,2-Dichloroethene	1	45
VOCs	trans-1,3-Dichloropropene	1	45
VOCs	Trichloroethene	1	134
VOCs	Trichlorofluoromethane	1	48
VOCs	Trichlorotrifluoroethane	na	12
VOCs	Vinyl acetate	1	12
VOCs	Vinyl chloride	1	54
VOCs	Vinylidene chloride	1	54
VOCs	Xylene	na	73
Conventionals	Acid Volatile Sulfides	na	73
Conventionals	Acid Volatile Sulfides	na	9
Conventionals	Calcium	na	195
Conventionals	Sodium	na	195
Conventionals	Total organic carbon	58	505
Conventionals	Total solids	58	445
Conventionals	Total sulfides	na	62
Conventionals	Total volatile solids	na	157
Petroleum	Diesel fuels	na	64
Petroleum	Gasoline	na	2
Petroleum	Heavy oil	na	2
Petroleum	Jet fuel A	na	2
Petroleum	JP-4 jet fuel	na	2
Petroleum	Kerosene	na	2
Petroleum	Lube oil	na	64
Petroleum	Mineral spirits	na	2

[a] Sample number excludes data that were rejected as a result of data validation.

[b] Historical surface sediment data includes samples collected from RM 2.0 to 9.2.

na – chemical not analyzed in sampling event

Table 3-2 Summary of fish and benthic invertebrate whole-body tissue samples collected at Round 1 sampling locations

SAMPLING LOCATION	SPECIES (number of composite samples collected at sampling location)
02R001	crayfish (1); sculpin (2)
02R015	crayfish (1); sculpin (1)
02R102	juvenile chinook salmon (1)
02R112	juvenile chinook salmon (1)
02R113	juvenile chinook salmon (1)
03R001	crayfish (1); sculpin (1)
03R002	crayfish (1); sculpin (2)
03R003	crayfish (1)
03R004	crayfish (1); sculpin (2)
03R005	crayfish (1); sculpin (1)
03R014	largescale sucker (2); northern pikeminnow (2); peamouth (1); smallmouth bass (1)
03R032	crayfish (1); sculpin (1)
03R034	sculpin (1)
03R118	juvenile chinook salmon (1)
03R125	juvenile chinook salmon (1)
04R002	crayfish (1); sculpin (1)
04R003	crayfish; sculpin (1)
04R004	crayfish (2); sculpin (1)
04R023	smallmouth bass (3); sculpin (1)
04R126	juvenile chinook salmon (1)
05R001	crayfish (1); sculpin (1)
05R003	crayfish (1)
05R006	largescale sucker (1); northern pikeminnow (1); peamouth (1); smallmouth bass (1)
05R020	sculpin (1)
06R001	crayfish (1); sculpin (1)
06R002	clam (1); sculpin (2)
06R004	crayfish (2); sculpin (1)
06R024	smallmouth bass (1)
06R031	crayfish (1)
07R003	clam (1); crayfish (1); sculpin (1)
07R004	crayfish (1)
07R006	clam (1); crayfish (1); sculpin (1)
07R009	smallmouth bass (3); largescale sucker (1); northern pikeminnow (1)
08R001	crayfish (1); sculpin (1)
08R002	crayfish (1); sculpin (1)
08R003	crayfish (1); sculpin (1)
08R010	smallmouth bass (3); largescale sucker (1); northern pikeminnow (1); peamouth (1)
08R032	smallmouth bass (1)

Table 3-2 Summary of fish and benthic invertebrate whole-body tissue samples collected at Round 1 sampling locations

SAMPLING LOCATION	SPECIES (number of composite samples collected at sampling location)
09R001	crayfish (2); sculpin (1)
09R002	crayfish (1); sculpin (1)
09R006	largescale sucker (1); northern pikeminnow (1); peamouth (1); smallmouth bass (1)
FZ0306	black crappie (2); brown bullhead (3); carp (3)
FZ0609	black crappie (2); brown bullhead (3); carp (4)

Table 3-3 Summary of Round 1 ERA tissue samples collected in the Portland Harbor Superfund Site

RECEPTOR OF CONCERN	NO. OF TISSUE COMPOSITE SAMPLES[a]	CHEMICALS ANALYZED IN TISSUE
Crayfish	27	dioxins, PCB congeners, metals, PAHs PCBs, chlorinated pesticides, SVOCs, VOCs
Clam	3	metals, TBT, PAHs, PCBs, chlorinated pesticides, SVOCs, VOCs
Largescale sucker	6	metals, PAHs, PCBs, chlorinated pesticides, SVOCs, VOCs
White sturgeon	0	na
Carp[b]	7	dioxins, PCB congeners, metals, PAHs PCBs, chlorinated pesticides, SVOCs, VOCs
Juvenile chinook salmon	6	metals, PAHs, PCBs, chlorinated pesticides, SVOCs, VOCs
Sculpin	27	dioxins, PCB congeners, metals, PAHs PCBs, chlorinated pesticides, SVOCs, VOCs
Peamouth	4	metals, PAHs, PCBs, chlorinated pesticides, SVOCs, VOCs
Smallmouth bass	14	dioxins, PCB congeners, metals, PAHs PCBs, chlorinated pesticides, SVOCs, VOCs
Northern pikeminnow	6	metals, PAHs, PCBs, chlorinated pesticides, SVOCs, VOCs
Pacific lamprey	0	na
Black crappie[c]	4	dioxins, PCB congeners, metals, PAHs PCBs, chlorinated pesticides, SVOCs, VOCs
Brown bullhead[c]	6	dioxins, PCB congeners, metals, PAHs PCBs, chlorinated pesticides, SVOCs, VOCs

[a] Whole-body tissue composites only

[b] Carp will be used as a surrogate ecological receptor only for dioxins and PCB congener data in whole-body tissue; ecological risks via tissue-residue exposure for all other chemicals and via dietary exposure will not be evaluated for carp.

[c] Whole-body tissue was collected for black crappie and brown bullhead in support of the HHRA and will be used in the dietary exposure calculations for fish and wildlife, but ecological risks (via tissue-residue and dietary exposure) will not be assessed for these two fish species.

na – not applicable; no tissue was collected for analysis

Table 3-4 Round 1 co-located sediment and tissue sampling locations in the Portland Harbor Superfund Site

LOCATION	SURFACE SEDIMENT SAMPLE	SCULPIN TISSUE SAMPLE	CRAYFISH TISSUE SAMPLE	CLAM TISSUE SAMPLE
02R001	X	X	X	
02R015	X	X	X	
03R001	X	X	X	
03R002	X	X	X	
03R003	X		X	
03R004	X	X	X	
03R005	X	X	X	
03R032	X	X	X	
03R034	X	X		
04R002	X	X	X	
04R003	X	X	X	
04R004	X	X	X	
05R001	X	X	X	
05R003	X		X	
05R020	X	X		
06R001	X	X	X	
06R002	X	X		X
06R004	X	X	X	
06R031	X		X	
07R003	X	X	X	X
07R004	X		X	
07R006	X	X	X	X
08R001	X	X	X	
08R002	X	X	X	
08R003	X	X	X	
09R001	X	X	X	
09R002	X	X	X	

Table 5-1 Dietary parameters for fish receptors in the PRE

ECOLOGICAL RECEPTOR SPECIES	SPECIES COLLECTED IN ROUND 1 TO REPRESENT PREY ITEMS	% SEDIMENT INGESTED[a]	% PREY INGESTED
Largescale sucker	crayfish, clam	50%	50%
Juvenile chinook salmon	crayfish, clam	0%	100%
Sculpin	crayfish, clam, juvenile chinook salmon, sculpin	30%	70%
Peamouth	crayfish, clam, juvenile chinook salmon, sculpin	5%	95%
Smallmouth bass	sculpin, peamouth, juvenile chinook salmon, crayfish, smallmouth bass, black crappie, brown bullhead	5%	95%
Northern pikeminnow	sculpin, peamouth, juvenile chinook salmon, smallmouth bass, largescale sucker, brown bullhead, northern pikeminnow, crayfish, black crappie, carp	5%	95%

[a] Based on best professional judgment considering feeding modes of fish receptor species.

Table 5-2 Dietary parameters for wildlife receptors in the PRE

ECOLOGICAL RECEPTOR SPECIES	BW (kg)	BW SOURCE	FIR (kg/day dw)	SI (% of dry diet)	SPECIES COLLECTED IN ROUND 1 TO REPRESENT PREY ITEMS
Spotted sandpiper	F = 0.047	Maxson and Oring (1980)	F = 0.0082[a]	18[b]	clams, crayfish
	M = 0.038		M = 0.0067[a]		
Hooded merganser	F = 0.54	Dunning (1993)	F = 0.055[c]	2[d]	sculpin, juvenile chinook salmon, clams, crayfish
	M = 0.68		M = 0.064[c]		
Bald eagle	F = 4.5	Wiemeyer 1991, as cited in EPA (1993)	F = 0.146[e]	2[d]	largescale sucker, smallmouth bass, northern pikeminnow, peamouth, brown bullhead, carp, crappie, sculpin, juvenile chinook salmon
	M = 3.0		M = 0.097[e]		
Osprey	F = 1.57	Brown and Amadon (1968)	F = 0.112[c]	2[d]	largescale sucker, smallmouth bass, northern pikeminnow, peamouth, brown bullhead, carp, crappie, sculpin, juvenile chinook salmon
	M = 1.4		M = 0.103[c]		
Mink	F = 0.55	Mitchell (1961)	F = 0.0238[f]	9.4[g]	sculpin, juvenile chinook salmon, smallmouth bass, largescale sucker, northern pikeminnow, peamouth, brown bullhead, crayfish, clams, carp, black crappie
	M = 1.04		M = 0.0412[f]		
River otter	F = 7.9	Melquist and Hornnocker (1983)	F = 0.238[f]	2[d]	sculpin, juvenile chinook salmon, smallmouth bass, largescale sucker, northern pikeminnow, peamouth, brown bullhead, crayfish, clams, carp, black crappie
	M = 9.2		M = 0.271[f]		

BW – body weight

FIR – food ingestion rate

SI – sediment ingestion

[a] FIR (kg/day) calculated from Nagy (2001), where common sandpiper FIR = 0.175 mg dw/mg bw/day.

[b] From Beyer et al. (1994), as presented in EPA (1993); range of sediment ingestion from 7.3-30% (average = 18%).

[c] FIR calculated from Nagy (2001); where FIR for carnivorous birds (g/day) = $0.849*BW^{0.663}$, and where BW = body weight in g .

[d] Based on best professional judgment; no data available.

[e] FIR calculated from Stalmaster and Gessaman (1982), where FIR = 12% of BW (ww); and % moisture in fish = 73%. (average % moisture in Round 1 whole-body fish tissue).

[f] FIR calculated from Nagy (2001), where FIR for carnivora (g/day) = $0.102*BW^{0.864}$, and where BW = body weight in g.

[g] From Beyer et al. (1994), as presented in EPA (1993); reported incidental sediment ingestion by raccoon.